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TRANSMITTAL

Applicant	:	K. Izumi
App. No.	:	10/791,353
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For	:	DRIVE SYSTEM FOR OFF-ROAD VEHICLE
Examiner	:	Unknown
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CERTIFICATE OF MAILING

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Transmitted herewith for filing in the above-identified application are the following enclosures:

(X) English translation of U.S. Provisional Application No. 60/460,070 filed April 2, 2003 in 27 pages.

(X) Verification of Translation.

(X) Return prepaid postcard.

(X) Please charge any additional fees, including any fees for additional extension of time, or credit overpayment to Deposit Account No. 11-1410.

William H. Shreve
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VERIFICATION OF TRANSLATION

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My name and post office address are as stated below:

That I am knowledgeable in the English language and in the language in which the below identified U.S. Provisional Application was filed, and that I believe the attached English translation of the U.S. Provisional Application No. 60/460,070 filed on April 2, 2003 is a true and complete translation of the above-identified Provisional Application as filed.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Date: 10 / 8 / 2004

Full Name of the Translator: Yasuhiro Tochigi

Signature of the translator: Yasuhiro Tochigi

Post Office Address: No. 28-17, Shogen, Hamamatsu, Shizuoka 430-0802, Japan

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[Document Name] Specification

[Title of the Invention] DRIVE UNIT FOR ALL-TERRAIN VEHICLE

[Claims]

[Claim 1] A drive unit for an all-terrain vehicle having a body frame provided with wheels on its right and left respectively in front and rear, for running over rugged terrains and an engine near its longitudinal center, wherein a front differential having a front differential gear for distributing and transmitting power taken directly out of the engine to right and left front wheels is adopted to function in three modes: two-wheel drive, four-wheel drive, and differential lock, and a rear differential having a rear differential gear for distributing and transmitting the power to right and left rear wheels is adopted to function in two modes: differential and differential lock.

[Claim 2] The drive unit for the all-terrain vehicle according to Claim 1, wherein an electric actuator type of front differential mode shifting device is provided to shift the mode of the front differential by operating a switch, while a manual type of rear differential mode shifting device is provided to shift the mode of the rear differential by handling a lever.

[Claim 3] The drive unit for the all-terrain vehicle according to Claim 2, wherein the front differential mode shifting device is enabled to lock the front differential only when the rear differential mode shifting device is in the differential lock mode.

[Claim 4] A drive unit for an all-terrain vehicle having a body frame provided with wheels on its right and left respectively in front and rear, for running over rugged terrains and an engine near its longitudinal center, further having front and rear differentials, with the former having a front differential gear for distributing and transmitting engine power transmitted through a front drive shaft to right and left front wheels, while the latter having a rear differential gear for distributing and transmitting engine

power transmitted through a rear drive shaft to right and left rear wheels, wherein the distance from the front power takeout portion of the engine to the front differential and the distance from the rear power takeout portion of the engine to the rear differential are set to different values respectively, and the engine power takeout portion, the transmission shaft, and a differential input shaft are aligned and joined together by spline fitting at least on the side where the distance is shorter.

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

This invention relates to a drive unit for an all-terrain vehicle, in particular to a four-wheel drive unit having front and rear differentials for distributing and transmitting power of an engine to right and left wheels in front and rear.

[0002]

[Prior Art]

Four-wheeled vehicles of this type for running over rugged terrains have a seat or two for two riders in about the center of the length of a body frame, an engine behind the seats, and its four-wheel drive unit is adapted to transmit the engine power from a front drive shaft dividedly to right and left front wheels through a front differential and from a rear drive shaft to right and left rear wheels through a rear differential (For example, see Patent Document 1).

[0003]

Some of the four-wheel drive units conventionally employ a differential locking mechanism to prevent differential rotation between right and left wheels, thereby preventing one of the right and left wheels from spinning on a muddy road or the like.

[0004]

[Patent Document 1]

JP-A-2000-103246

[0005]

[Problems to be Solved by the Invention]

However, the conventional drive unit described above has a problem that, even if the differential on the rear wheels is in the locked mode, the differential on the front wheels is operative, and performance in running over rugged terrains is restricted. Here, while locking both the front and rear differentials may be thought of, locking all the wheels is impracticable because a center differential is present in the output portion of the engine. In any case, there is another problem in running through adverse road conditions such as with snow, uphill, and the like.

[0006]

This invention has been made to solve the above problems. It is therefore an object of the invention to provide a drive unit for an all-terrain vehicle that makes it possible to improve rough road running performance by reliably performing all wheel locking.

[0007]

[Means for Solving the Problems]

The invention of Claim 1 is characterized by a drive unit for an all-terrain vehicle having a body frame provided with wheels on its right and left respectively in front and rear, for running over rugged terrains and with an engine near its longitudinal center, wherein a front differential having a front differential gear for distributing and transmitting power taken directly out of the engine to right and left front wheels is adopted to function in three modes: two-wheel drive, four-wheel drive, and differential lock, and a rear differential having a rear differential gear for distributing and transmitting the power to right and left rear wheels is adopted to function in two modes: differential and differential lock.

[0008]

Here, as for the front differential, the "two-wheel drive

mode" is the mode in which power is not transmitted to the front wheels to set free the front wheels, and transmitted only to the rear wheels through the rear differential. The "four-wheel drive mode" is the one in which power is transmitted to the front wheels through the front differential. The "differential lock mode" is the one, the so-called direct connection mode, in which power is transmitted to the front wheels with the differential gear made inoperative. The "differential mode" for the rear differential is the one in which power is transmitted to the rear wheels through the differential gearing.

[0009]

Also here, the phrase "power taken directly out of the engine" means the power taken out without intervention of a center differential.

[00010]

The invention of Claim 2 is characterized by the drive unit for the all-terrain vehicle according to Claim 1, wherein an electric actuator type of front differential mode shifting device is provided to shift the mode of the front differential by operating a switch, while a manual type of rear differential mode shifting device is provided to shift the mode of the rear differential by handling a lever.

[0011]

The invention of Claim 3 is characterized by the drive unit for the all-terrain vehicle according to Claim 2, wherein the front differential mode shifting device is enabled to lock the front differential only when the rear differential mode shifting device is in the differential lock mode.

[0012]

The invention of Claim 4 is a drive unit for an all-terrain vehicle similar to that according to Claim 1 having front and rear differentials, with the former having a front differential gear for distributing and transmitting engine power transmitted through a front drive shaft to right and left

front wheels, while the latter having a rear differential gear for distributing and transmitting engine power transmitted through a rear drive shaft to right and left rear wheels, wherein the distance from the front power takeout portion of the engine to the front differential and the distance from the rear power takeout portion of the engine to the rear differential are set to different values respectively, and the engine power takeout portion, the transmission shaft, and a differential input shaft are aligned and joined together by spline fitting at least on the side where the distance is shorter.

[0013]

[Effects of the Invention]

According to the drive unit of the invention described in Claim 1, power is taken out of the engine directly without intervention of a center differential, and the front differential is adapted to function in three modes: two-wheel drive, four-wheel drive, and differential lock. Therefore, all the wheels may be locked by setting the front and rear wheels to the differential lock mode to improve running property under adverse road conditions such as with snow, uphill, etc.

[0014]

According to Claim 2, only the front differential that is shifted frequently is made to be of an electrically actuated type while the rear differential that is shifted less frequently is made to be of a manually operated type. Therefore, the effect provided according to Claim 1 is also provided by means of an inexpensive system.

[0015]

According to Claim 3, the front differential mode is shifted electrically and the front wheels may be set to the differential lock mode only when the rear wheels are in the differential lock mode. Therefore, control of simultaneously locking the front and rear differentials is realized with an inexpensive system for detecting the mode on only the rear wheels side.

[0016]

According to Claim 4, at least on the side where the distance between the engine power takeout portion and the differential is shorter, the power takeout portion, the transmission shaft, and the differential input shaft are aligned and interconnected through spline fitting. Therefore, engine power may be transmitted to the differential gear without using connecting members such as universal joints. Corresponding to the disuse of the universal joints, cost and weight of the vehicle are reduced, and total vehicle weight distribution in front and rear is improved.

[0017]

[Embodiment of the Invention]

An embodiment of the present invention is described with reference to the attached figures.

[0018]

Figs. 1 to 7 illustrate a drive unit for an all-terrain vehicle according to an embodiment (first embodiment) of the present invention. Figs. 1 and 2 are side and plan views respectively of the all-terrain vehicle provided with the drive unit of this embodiment. Fig. 3 is a side view of the vehicle with an engine unit mounted. Fig. 4 is a cross-sectional view of the rear power takeout portion of the engine unit. Fig. 5 is a constitutional plan view of the engine unit. Figs. 6 and 7 are side and plan views respectively of the shift mechanism. Incidentally, the terms "right," "left," "front" and "rear" are meant as seen by a seated rider.

[0019]

In the figures, the reference numeral 1 indicates an all-terrain vehicle. The vehicle 1 has front and rear wheels 3 and 4, on four corners of the body frame 2, front right and left and rear right and left, each having a balloon tire for running over rugged terrains. The vehicle 1 has a seat 5, for two riders, positioned in the longitudinal center of the body frame 2. The seat 5 is provided with right and left seat pieces.

An engine unit 6 is mounted below the seat 5.

[0020]

The body frame 2 is provided with a drive unit 11 for distributing the power of the engine unit 6 to front and rear drive shafts 7, 8 and further dividedly transmitting through front and rear differentials 9 and 10 to the front and rear wheels 3, 4. The body frame 2 is further provided with a steering device 13 for transmitting turning motion of a steering wheel 12 disposed in front of the seat 5 to the right and left front wheels 3 through a steering shaft 55. The front and rear suspension devices 14, 15 suspending the right and left front wheels 3 and right and left rear wheels 4 are capable of independently swinging up and down.

[0021]

A hood 16 is provided in the front area of the body frame 2 to be opened and closed. A deck 17 is provided behind the seating 5.

[0022]

The body frame 2 is provided with a main frame 20, a front frame 21, a rear frame 22, and pillar frames 24, 24. The main frame 20 includes right and left side members 18, 18 interconnected through three cross members 19 at front, center and rear portions of the side members 18, 18. The front frame 21 stands on the front portion, while the rear frame 22 stands on the rear portion of the main frame 20. The pillar frames 24, 24 are provided on right and left sides of the main frame 20 to form a riders' compartment together with a floor panel 23.

[0023]

The floor panel 23 is disposed between the front frame 21 and the rear frame 22 of the main frame 20 to bridge the right and left pillar frames 24, 24.

[0024]

The seat 5 is split into a left seat 30 and a right seat 31. The left and right seats 30, 31 are detachably attached to the

top front portion of the rear frame 22 with a lateral spacing in between. The seats 30, 31 comprise seat cushions 30a, 31a detachably attached to the rear frame 22 together with their integrally formed seatbacks 30b, 31b. The steering wheel 12 is positioned in front of the left seat 30. A shift lever 42 is disposed in the front part of the space between the left and right seats 30, 31. The shift lever 42 is to be shift-operated to positions of parking, forward H-N-L, and reverse, and is connected through a linkage 41 to a shift mechanism 34 which will be described later.

[0025]

The engine unit 6 includes a water-cooled, four-stroke, single cylinder engine 35, and a transmission case 38 joined to the front part of the engine 35. The transmission case 38 includes a crankcase 37a and a belt case 36a, with the former containing a crankshaft 37 while the latter containing a V-belt type continuously variable transmission 36. The engine 35 is constituted by placing one over another: the crankcase 37a containing the crankshaft 37 extending transversely and horizontally, a cylinder block 35b, a cylinder head 35c, and a head cover 35d. The cylinder head 35c has in its front wall 35e an intake port 35f, and in its rear wall 35g a pair of exhaust ports 35h.

[0026]

The belt case 36a is connected to the left wall of the crankcase 37a to enclose the V-belt type continuously variable transmission 36. The continuously variable transmission 36 is constituted with a drive pulley 36d attached to the crankshaft 37, a driven pulley 36b attached to an output shaft 39 extending parallel to the crankshaft 37, and a V belt 36c routed around the drive pulley 36d and the driven pulley 36b. The engine output is transmitted from the output shaft 39 to the front and rear drive shafts 7, 8 through a high-low and forward-reverse shift mechanism 34 contained in the crankcase 37a, and a bevel gear 40. The rear wall of the belt case 36a

has an air inlet 36e through which air for cooling is drawn in, while the front wall of the belt case 36a has an air outlet 36f through which air is discharged.

[0027]

The engine unit 6 is mounted on the rear frame 22 so that the output shaft 39 is positioned in front of the crankshaft 37. The crankshaft 37 and the output shaft 39 are placed below the seat 5, and the centerline of the engine unit 6 extends between the left and right seats 30, 31 in the vehicle width center.

[0028]

Most part of both the cylinder block 35b and the cylinder head 35c of the engine 35 is placed behind the rear ends of the seatbacks 30b, 31b of the left and right seats 30, 31 as seen in the left side view. The cylinder axis A extends up aslant with a slant angle of, for example, about 45 degrees relative to the horizontal.

[0029]

An air intake device 45 extending forward is connected to the front wall 35e, while an exhaust device 46 extending rearward is connected to the rear wall 35g. The exhaust device 46 is provided with a pair of exhaust pipes 47, 47 connected respectively to the rear wall 35g connected in turn to the exhaust ports 35h, and a muffler 48 connected to the downstream ends of the exhaust pipes 47. Each exhaust pipe 47 has a wavy shape that winds up and down in the side view. The muffler 48 is disposed to extend transversely near the rear end of the body frame 2.

[0030]

The intake device 45 is constituted such that the downstream end of the throttle body 50 is connected to the front wall 35e through an intake pipe 49 connected in turn to the intake port 35f. The down stream end of the intake duct 51 is connected to the upstream end of the throttle body 50 through an accumulator 53. An air cleaner 52 is connected to the upstream

end of the intake duct 51.

[0031]

The throttle body 50 contains a throttle valve 50a that opens and closes an intake passage. An accelerator pedal 32 is connected to the throttle valve 50a through a throttle control cable. The air cleaner 52 is disposed near the inside surface of the hood 16 between the right and left front wheels 3.

[0032]

According to the engine unit mounting structure in the illustrated embodiment, because the engine unit 6 is mounted with the output shaft 39 and the crankshaft 37 positioned below the seat 5 and the output shaft 39 positioned fore side than the crankshaft 37, the cylinder head 35c results in facing toward the rear. The engine unit 6 thus can be mounted on the body frame 2 with only small rearward protrusion without interfering with the seat 5 or the riders' feet. As a result, the wheelbase can be shortened, so that the vehicle body can be made compact.

[0033]

Because the cylinder head 35c faces rearward, the engine heat is prevented from affecting the riders, and the rider can easily move from one seat to the other between the left and right seats 30, 31.

[0034]

In the illustrated embodiment, part of the cylinder block 35b and the cylinder head 35c of the engine 35 is made to project rearward of the rear ends of the seatbacks 30b and 31b, and the cylinder axis A is made to extend obliquely upward. Therefore, the cylinder block 35b and the cylinder head 35c both having much heat can be spaced apart from the seat 5 or the riders, so that adverse influence of the engine heat is avoided.

[0035]

Next, the drive unit 11 is described.

[0036]

The front differential 9 and the rear differential 10 are located in about the lateral center of the body frame 2 and in about the same height as the engine unit 6. This makes it possible to set the vehicle's center of gravity at a low height while retaining a minimum ground clearance.

[0037]

The front differential 9 is constituted that left and right drive shafts 9b, 9b are connected through a differential gear (not shown) to a differential input shaft 9a. The front end of the front drive shaft 7 is connected through a universal joint to the rear end of the differential input shaft 9a. The left and right drive shafts 9b, 9b are connected to the front wheels 3, 3. The rear differential 10 is constituted that left and right drive shafts 10b, 10b are connected through a differential gear (not shown) to a differential input shaft 10a. The front end of the differential input shaft 10a is connected to the rear end of the rear drive shaft 8. The drive shafts 10b, 10b are connected to the rear wheels 4,4. Thus, power of the engine is transmitted dividedly from the front and rear drive shafts 7, 8 through the front and rear differentials 9, 10 to the front wheels 3, 3 and rear wheels 4, 4 on left and right sides.

[0038]

The power takeout portion of the engine unit 6 has no center differential in constitution, so that power of the engine is taken out directly from an output shaft 39 and transmitted through a bevel gear 40 and divided between a front power takeout shaft 43 and a rear power takeout shaft 44.

[0039]

Both the power takeout shafts 43, 44 are disposed coaxially and interconnected by spline fitting. The front power takeout shaft 43 is connected to the rear end of the front drive shaft 7, while the rear power takeout shaft 44 is connected to the front end of the rear drive shaft 8.

[0040]

The distance from the front power takeout shaft 43 of the engine unit 6 to the front differential 9 is set to be greater than the distance from the rear power takeout shaft 44 to the rear differential 10.

[0041]

The rear power takeout shaft 44, the rear drive shaft 8, and the rear differential input shaft 10a are aligned to be approximately horizontal. The front end of the rear drive shaft 8 and the rear end of the rear power takeout shaft 44 are interconnected through a spline coupling 61, while the rear end of the rear drive shaft 8 and the front end of the rear differential input shaft 10a are interconnected through another spline coupling 61. The connection through the spline coupling permits slight relative motion in both axial and swinging directions but no relative rotary motion.

[0042]

The spline coupling 61 is constituted as shown in Fig. 4 with a cylindrical base 61a having an integrally formed, cylindrical part 61b larger in diameter than the base 61a, with inside round surface of the cylindrical part 61b provided with arcuate inside keyways 61c. The rear drive shaft 8 is inserted in the base 61a by spline fitting, with the front end of the rear drive shaft 8 secured to the spline coupling 61 by means of a nut 62. The rear end portion of the rear power takeout shaft 44 is formed with arcuate outside keyways 44a to engage with the arcuate inside keyways 61c. The above constitution permits some amount of vertical and lateral swing of the rear power takeout shaft 44 and the rear drive shaft 8.

[0043]

The front differential input shaft 9a is displaced laterally to the left as seen in plan view in relation to the front power takeout shaft 43. The front drive shaft 7 is connected through a universal joint 63 to the front differential input shaft 9a connected in turn through another universal joint 63 to the front power takeout shaft 43, to permit vertical and lateral

swing. The universal joint 63 is constituted as shown in Fig. 3 such that first yoke 63a spline-fit to the front power takeout shaft 43 and a second yoke 63b spline-fit to the front drive shaft 7 are interconnected through a cross-pin 63c.

[0044]

The front differential 9 is provided with a front differential mode shifting device 70 for shifting to any of three modes: two-wheel drive, four-wheel drive, and differential lock. The rear differential 10 is provided with a rear differential mode shifting device 71 for shifting to either of two modes: differential and differential lock.

[0045]

The front differential mode shifting device 70 is of an electric actuator type for shifting the mode by operating a push button type of shift switch 72 provided at the driver's seat. The rear differential mode shifting device 71 is of a manually operated mechanical type for shifting the mode by handling an operation lever 73 provided at the driver's seat.

[0046]

The front differential mode shifting device 70 is adapted to be able to lock the front differential 9 only when the rear differential mode shifting device 71 is in the locking mode. That is to say, it is constituted that the front differential 9 may be locked by handling the switch, only when the operation lever 73 is in the differential lock position.

[0047]

With the drive unit according to this embodiment, engine power is transmitted directly, not through a center differential, dividedly to the front wheels 3 and the rear wheels 4. The front differential 9 is provided with the front differential mode shifting device 70 for shifting the mode to any of the three modes: two-wheel drive, four-wheel drive, and differential lock. The rear differential 10 is provided with the rear differential mode shifting device 71 for shifting to either of the two modes: differential and differential lock.

Therefore, an all-wheel locked mode may be brought about by setting the front wheels 3 and rear wheels 4 to the differential lock mode to improve running performance on rough roads covered with snow, having steep gradients, or the like.

[0048]

In this embodiment, the front differential mode shifting device 70 is adopted to be of the electric actuator type operated with a switch while the rear differential mode shifting device 71 is adopted to be of the manual operation type handled with a lever. That is to say, only the front differential mode shifting device that is shifted frequently is made to be of the electric actuator-operated type while the rear differential mode shifting device that is shifted less frequently is made to be of the manually operated type, so that the all-wheel locked mode may be realized with an inexpensive system.

[0049]

Since the front differential mode shifting device 70 is made to be of the electric actuator type and adapted to be capable of locking the front differential only when the operation lever 73 is in the position for locking the rear differential, the control of simultaneous locking of both the front and rear differentials 9, 10 may be effected with an inexpensive system that has only to detect the mode on the rear wheels side.

[0050]

With the drive unit according to this embodiment, since the rear power takeout shaft 44 of the engine unit 6, the rear drive shaft 8, and the rear differential input shaft 10a are aligned and interconnected through the spline couplings 61, engine power may be transmitted without using universal joints to the rear differential 10. The disuse of the universal joints results in corresponding reduction in cost, vehicle weight, and further in favorable, front-to-rear, overall vehicle weight distribution.

[0051]

While the above embodiment is described as constituted that the rear power takeout shaft 44, the rear drive shaft 8, and the rear differential input shaft 10a, for interconnecting the engine unit 6 and the rear differential 10, are aligned, the drive unit according to this invention is not limited to the above constitution but may be constituted as follows.

[0052]

Figs. 8 and 9 are for explaining another drive unit as the second embodiment of this invention. In the figures, the same reference numerals as those in Figs. 1 and 2 indicate the same or similar parts.

[0053]

This second embodiment is constituted that, along with the aligned positioning of the rear power takeout shaft 44, the rear drive shaft 8, and the rear differential input shaft 10a, the front power takeout shaft 43, the front drive shaft 7, and the front differential input shaft 9a for interconnecting the engine unit 6 and the front differential 9 are disposed in mutual alignment, and spline couplings 61 are used to interconnect the three shafts. In this way, universal joints become unnecessary not only on the rear side but also on the front side, so that cost and vehicle weight are further reduced.

[Brief Description of the Drawings]

Fig. 1 is a side view for explaining an all-terrain vehicle as an embodiment of the present invention.

Fig. 2 is a plan view of the all-terrain vehicle.

Fig. 3 is a side view of an engine unit mounted on the all-terrain vehicle.

Fig. 4 is a side view of a steering device of the all-terrain vehicle.

Fig. 5 is a plan view of the constitution of the engine unit.

Fig. 6 is a side view of a shift mechanism of the engine unit.

Fig. 7 is a plan view of the shift mechanism.

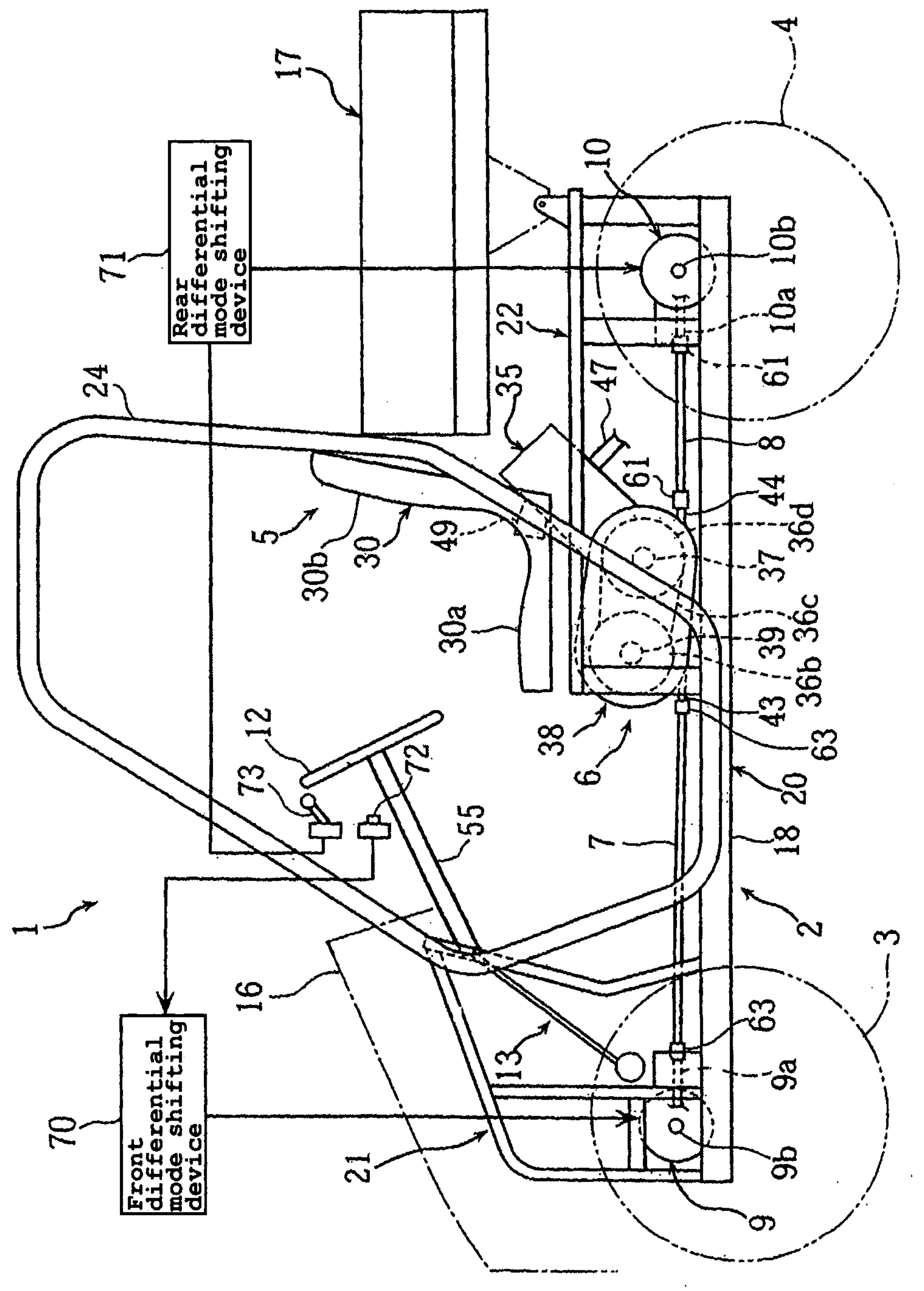
Fig. 8 is a side view of the all-terrain vehicle provided

with a drive unit as the second embodiment of the invention.

Fig. 9 is a plan view of the all-terrain vehicle above.

[Description of Reference Numerals]

1	all-terrain vehicle
2	body frame
3	front wheel
4	rear wheel
5	seat
6	engine unit
7	front drive shaft (front transmitting shaft)
8	rear drive shaft (rear transmitting shaft)
9	front differential
9a	front differential input shaft
10	rear differential
10a	rear differential input shaft
43	front power takeout shaft
44	rear power takeout shaft
61	spline member
70	front differential mode shifting device
71	rear differential mode shifting device
72	shifting switch
73	operation lever


Rear differential mode shifting device
Front differential mode shifting device
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9a
9b
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30a
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FIG. 1

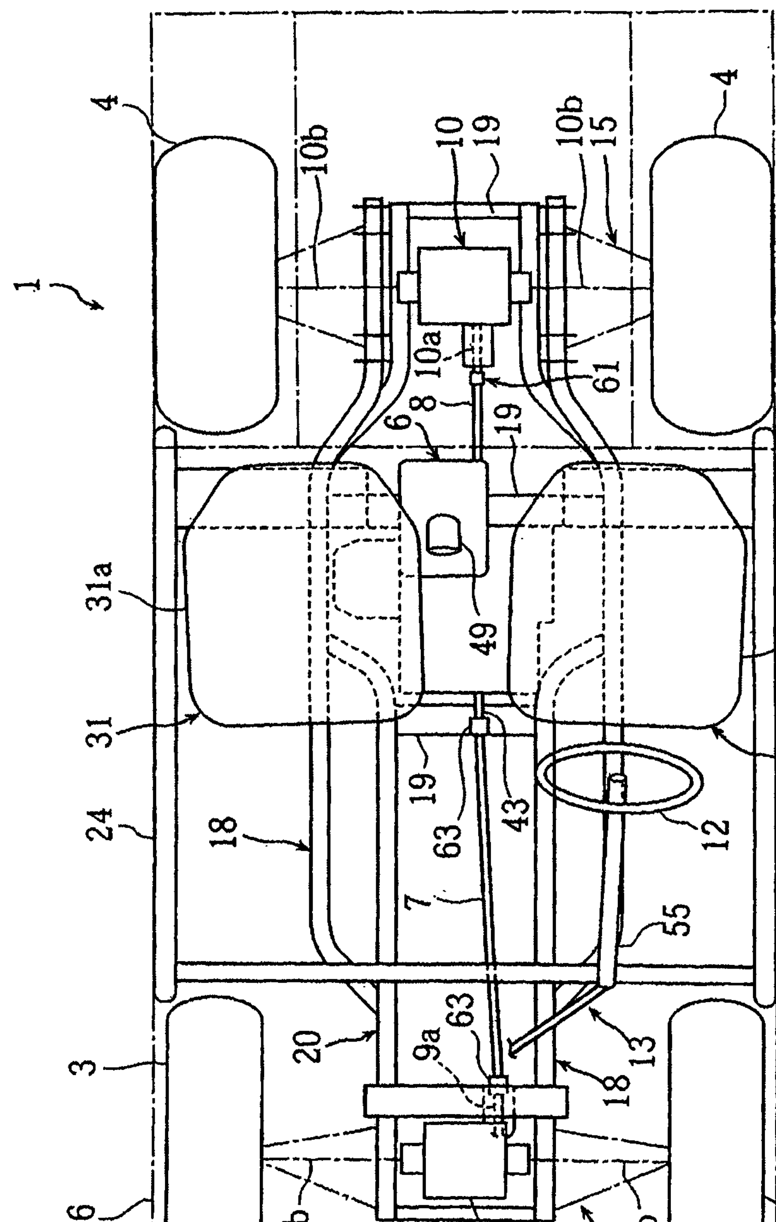
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FIG. 2

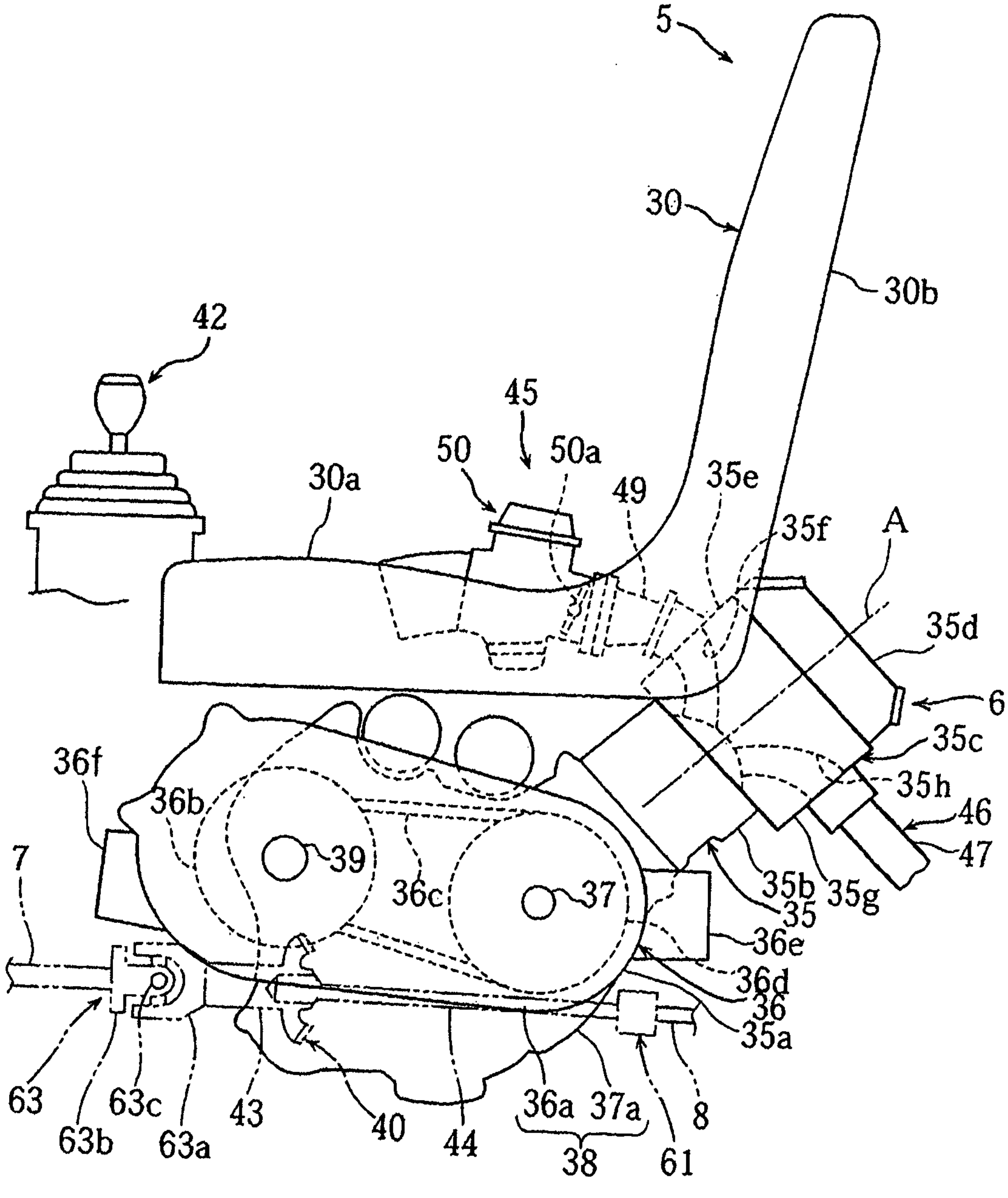
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FIG. 3

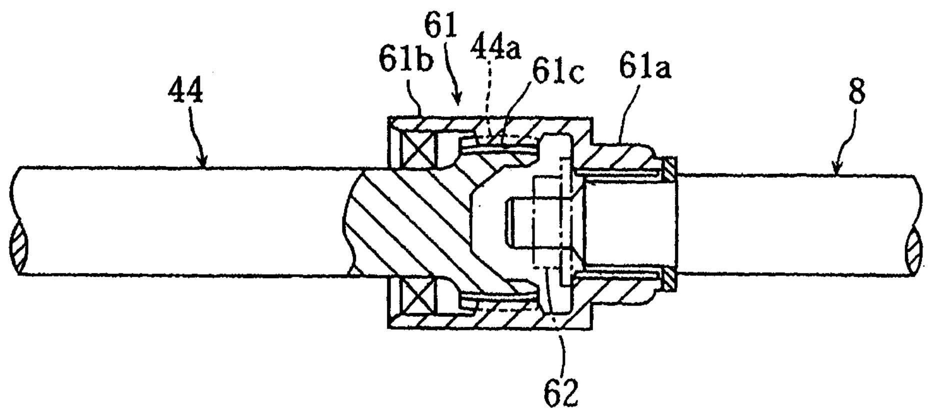

FIG. 4

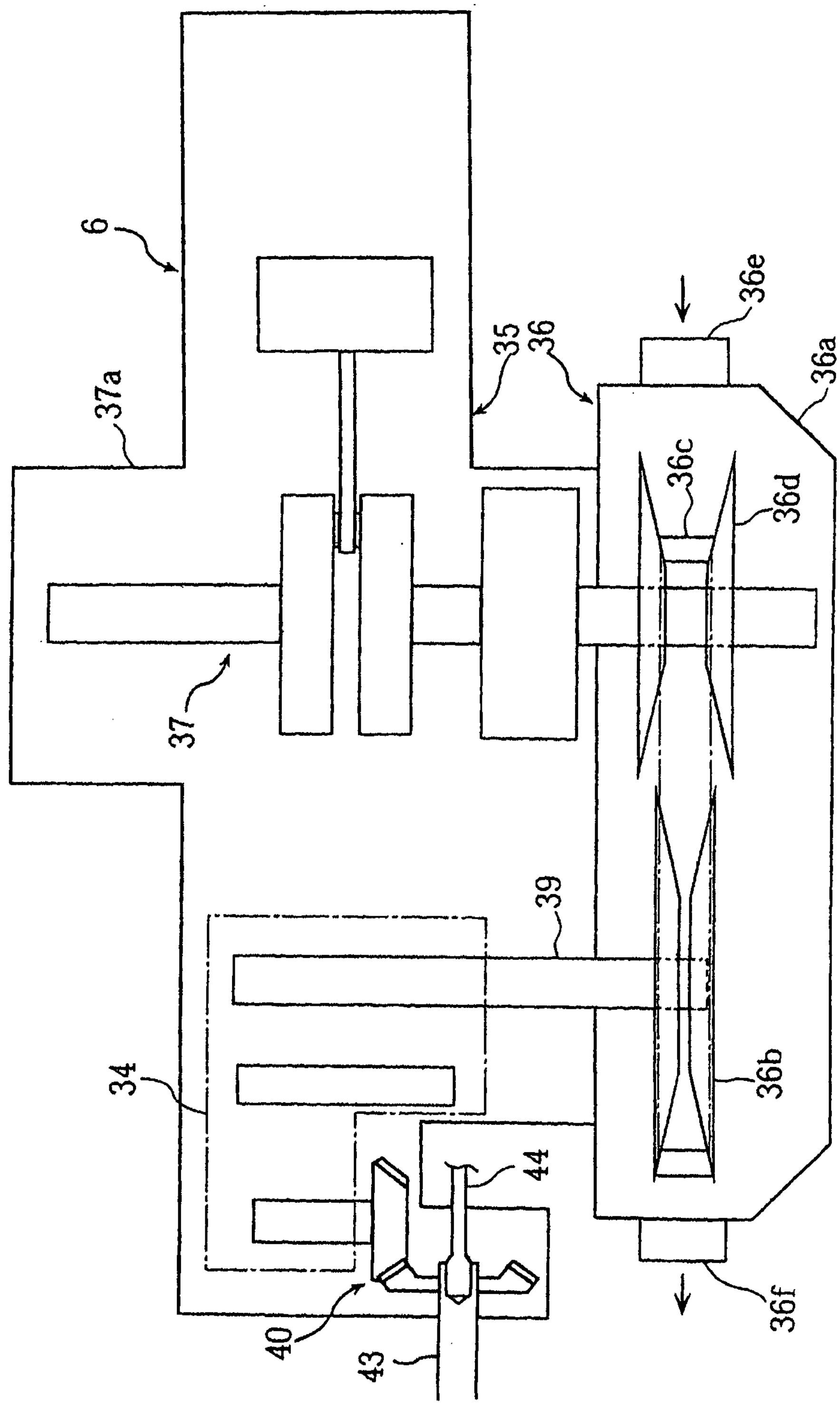

FIG. 5

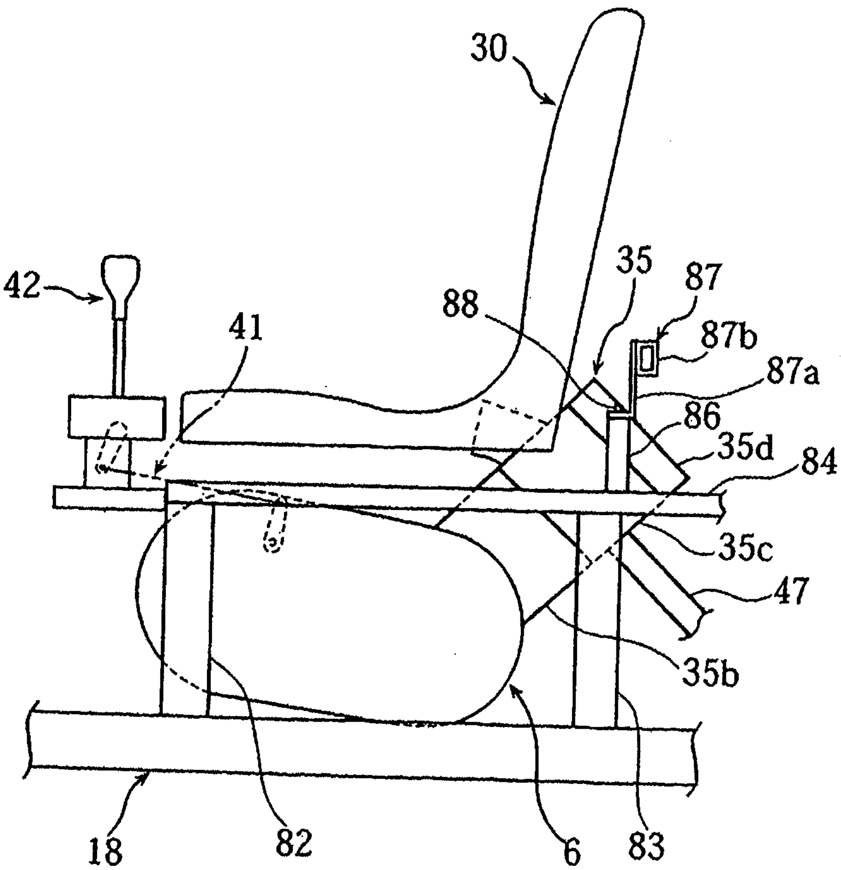

FIG. 6

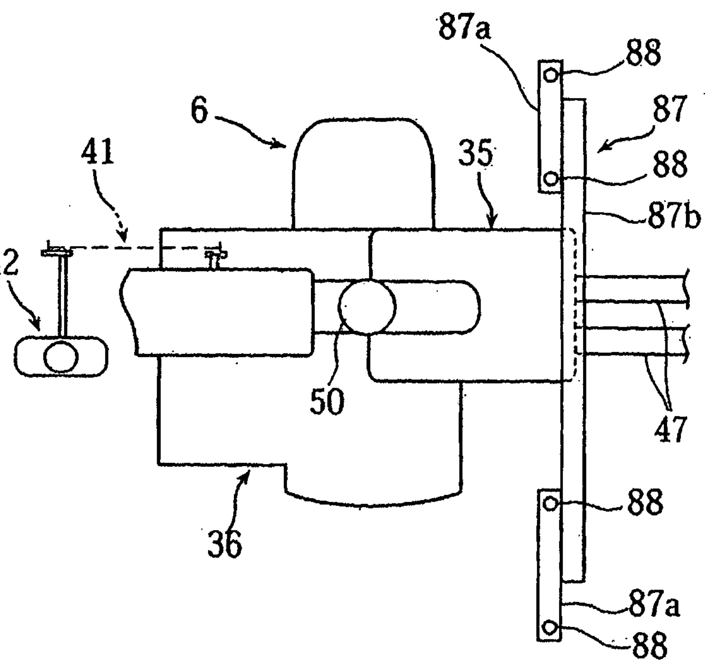

FIG. 7

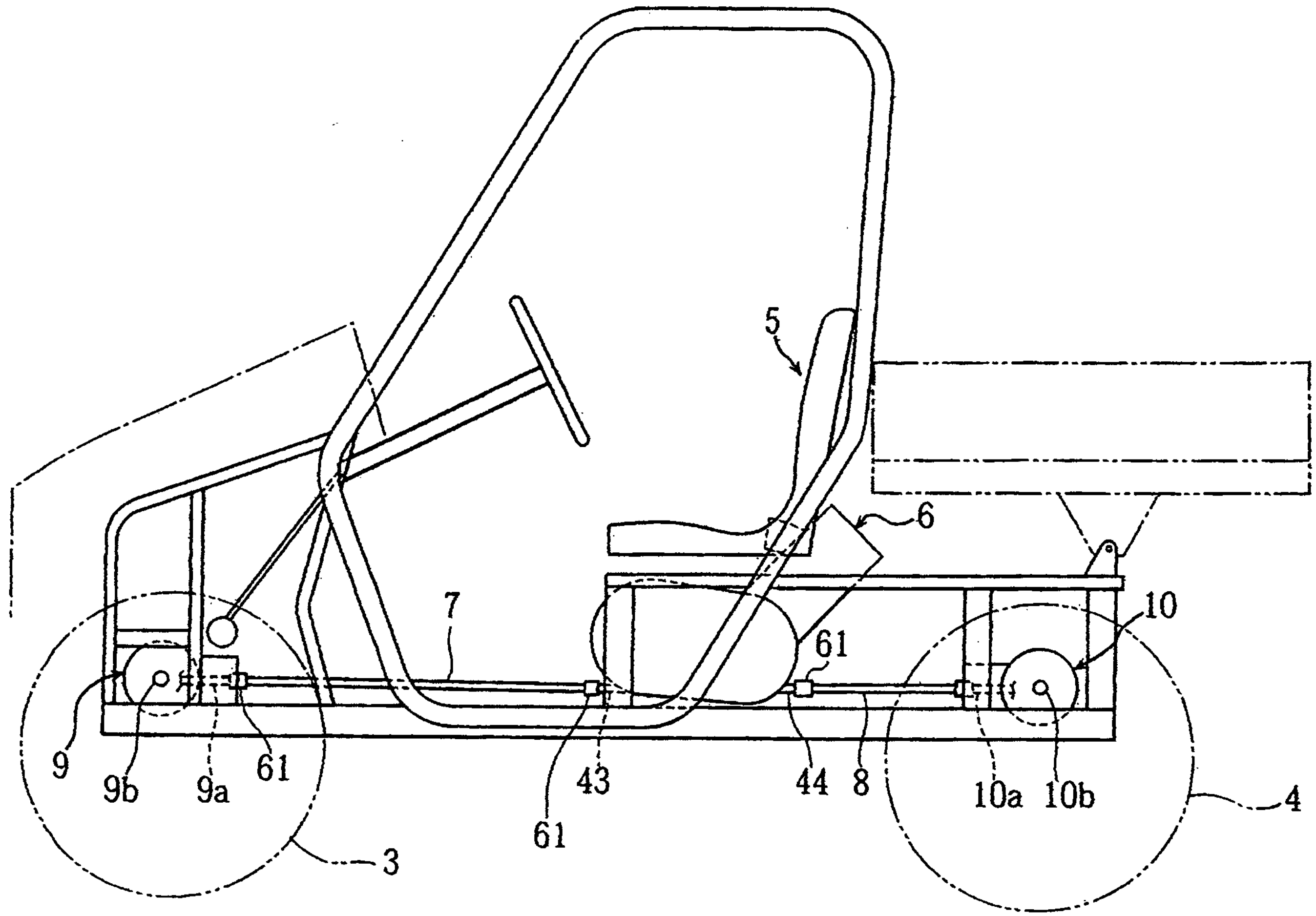

FIG. 8

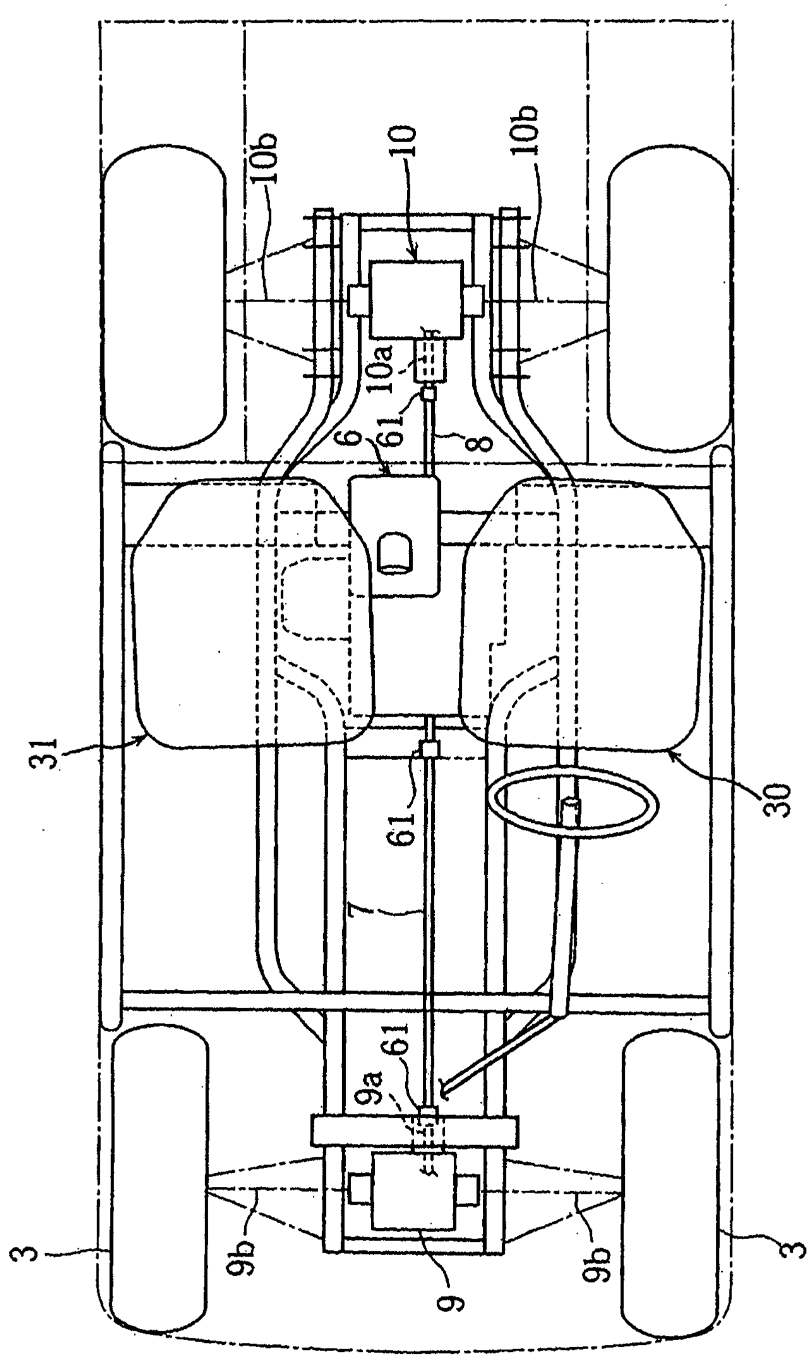

FIG. 9

[Document Name] Abstract

[Abstract]

[Problem to be Solved] To provide a drive unit for an all-terrain vehicle capable of improving running performance on rough roads by securely performing all-wheel lock of front and rear wheels.

[Solution] A front differential 9 for distributing and transmitting power taken directly out of the engine to right and left front wheels 3 has a front differential mode shifting device 70 for shifting to any of three modes: two-wheel drive, four-wheel drive, and differential lock, and a rear differential 10 for distributing and transmitting the power to right and left rear wheels 4 has a rear differential mode shifting device 71 for shifting to either of two modes: differential and differential lock.

[Selected Drawing] Fig. 1